HOW NEWTON'S LAW OF GRAVITY (THE LAW OF TWO-BODY GRAVITY) CAME TO BE CALLED THE LAW OF UNIVERSAL GRAVITATION.

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Abstract. *This article attempts to dispel the biggest myth that has surrounded Newton's law of gravitation for over 300 years. It reveals the history of the term "law of universal gravitation" in physics and the consequences of its unjustified application to the law of two-body gravity. The role of Robert Hooke and his astonishing intuition, which paved the way for him to formulate the actual law of universal gravitation, is revealed in a new light.*

Keywords: *Robert Hooke; Isaac Newton; astronomy; Newton's law of gravitation*

1. Introduction

The term "Law of Universal Gravitation" is often associated with Newton, although it was first proposed by Robert Hooke long before the publication of Philosophiae Naturalis Principia Mathematica. It is well known that Robert Hooke, with his remarkable intuition and broad interests, served as the intellectual catalyst for Newton's discovery of the law of gravitation. Hooke viewed the force of universal gravitation as a gravitational force exerted on all bodies by all other celestial bodies.

In a letter to Newton in 1679, Robert Hooke pointed out that the law of universal gravitation must take into account the elliptical orbits of the planets and the inverse-square law. This was the first verbal formulation of the law of universal gravitation in the history of science. It was Hooke's fateful 1679 letter that changed Newton's thinking.

In 1687, Newton presented his verbal formulation of the law of gravitation, which included the inverse-square law. However, the parameters of the elliptical orbit discussed by Hooke were not included in his law of gravitation. Instead of orbital parameters, Newton introduced mass into his law. As a result, instead of a law of universal gravitation for all bodies in the universe based on the orbital motion of bodies, Newton proposed a law of two-body gravitation based on the mass of the gravitating body. This radically differed from Hooke's verbal formula. Newton's two-body law of gravitation did not take into account the additional attractive force of all other bodies in the universe, which Hooke emphasized in his verbal formula.

The euphoria of Newton's supporters over the discovery of the law of gravitation was so great that they began to unjustifiably call the law of two-body gravitation the law of universal gravitation. Although this was Hooke's term, it referred not to the law of gravitation between two bodies, but to the attraction between all bodies in the universe. This "substitution" of terms led to Hooke's contribution remaining in the shadows for a long time. But the most destructive consequence of this “substitution” of terms was that the real law of universal gravitation, as Robert Hooke envisioned it, was never discovered.

2. Two different verbal formulas for the law of universal gravitation.

In the history of science, there have been two different verbal formulas for the law of universal gravitation. The first verbal formula for the law of universal gravitation in the history of science was given by Robert Hooke in a letter to Newton [1]. This occurred in 1679, seven years before the publication of Philosophiae Naturalis Principia Mathematica. In his verbal formula, Robert Hooke indicated that the law of universal gravitation must take into account the orbits of the planets and the inverse-square law. Hooke constantly studied the orbital motion of the planets. He believed that the orbital motion of the planets is determined by the force of universal gravitation. He viewed the force of universal gravitation as a gravitational force acting on all bodies from all other celestial bodies.

Newton's verbal formula was different. Newton pointed out the proportionality of force to the masses of bodies and the inverse-square law. The symbolic representation of Newton's law of gravity looks like this:

$$F_N \propto \frac{mM}{r^2} \qquad (1)$$

Where: F_N is the force, m, M are the masses of the bodies, r is the distance, $\propto$ is the proportionality sign.

Newton didn't assign any numerical value to the gravitational force. This wasn't a precise law of gravity, but a proportional relationship. In this incomplete form, Newton's law existed for almost 200 years. It became a precise equation in the form:

$$F=GmM/r^2 \qquad (2),$$

it was transformed only after the introduction of the gravitational constant G [2 -5].

Formulas (1) and (2) describe the attraction of only one local source of gravity and do not take into account that bodies simultaneously gravitate toward all other bodies. Formulas (1) and (2) describe the local gravity of two bodies and "miss" the additional gravitational force that actually exists as a result of the gravitational action of all bodies in the universe. The law of gravitation $F = GmM/r^2$ is the law of two-body gravity, applicable to closed elliptical orbits, which do not actually exist in the universe.

Even before 1679, Hooke spoke of " *attraction which is universal*." He understood gravity as the general attraction of everything to everything else. He distinguished between the local gravity of two bodies and universal attraction. Hooke believed that the force of universal gravitation was "*encoded*" in the orbital motion of the planets. Hooke shared this knowledge with Newton in 1679. Newton did not accept Hooke's hint [1]. Newton did not use orbital parameters in his law of gravitation; he was seeking a solution to the two-body gravitational problem.

In his letter to Newton, Hooke expected Newton to formulate a universal law of gravitation that takes into account the orbital motion of bodies. But instead of a law of universal gravitation based on the orbital motion of bodies, Newton proposed a proportional relationship $F_N \propto mM/r^2$, based on the mass of the gravitating body. The revised law $F = GmM/r^2$ still remained the law of two-body gravitation. It applies only to closed orbits, whereas real planetary orbits are not closed. This is precisely the point in Newtonian dynamics where Newton's mathematical justification of gravity

collided with the harsh "physical reality" of the universe. Ideal ellipses (closed orbits) are possible only in Newton's two-body problem. But the real universe does not consist of two bodies. Planets do not move in closed orbits.

3. Hooke's terminology as applied to universal gravitation.

Hooke first discussed gravity as a universal force that gives celestial bodies their spherical shape in 1665 in his book Micrographia. In Micrographia, he does not yet use the precise formulation "*universal attraction*," but he lays the foundation for this idea by discussing gravity as a universal property of matter to aggregate into spheres. In his "Observation VI", Hooke makes a bold proposition for his time: "*...Attraction is common not only to the Earth, Sun, Moon, and Planets, but to every minute body in the Universe...*" [6].

In 1674, in his work "*An Attempt to Prove the Motion of the Earth from Observations*," Hooke already wrote about "attraction which is universal." He asserted that all celestial bodies exert a force of attraction toward their centers and that they also attract all other celestial bodies. Instead of "*universal gravitation*," he used the term "*universal attraction*."

Newton found a solution to the two-body gravity problem that only approximates the actual gravitational force of the entire Universe. In the universe, there is no isolated gravitational interaction between two bodies. All bodies in the universe participate in gravitational interaction. This discovery is due to Robert Hooke. The gravitational force of two bodies always has an "addition." This "addition" is the gravitational force of all other bodies in the Universe. The Law of gravity $F = GmM/r^2$ "doesn't see" these "additions." The Law of gravity $F = GmM/r^2$ is applicable only on small scales, where the contribution of the force F to the universal gravitational attraction is greatest.

Thus, the problem of discovering the law of universal gravitation, as outlined by Hooke in his verbal formula, remains unsolved. In the minds of scientists and laymen, the formula for the gravitational force of all bodies in the universe has been replaced by the formula for the gravitational force of two bodies: $F = GmM/r^2$. This reinforced the illusion that the law of universal gravitation had been discovered and there was nothing more to discover. The formula for the gravitational force of two bodies, $F = GmM/r^2$, unjustifiably replaced the formula for the force of universal gravitation. All of the above shows that calling the law of universal gravitation of two bodies ($F = GmM/r^2$) the law of universal gravitation is a gross exaggeration. The law of universal gravitation remains undiscovered.

4. The N-body gravitational problem as an attempt to provide a realistic description of the gravity of the Universe.

The N-body gravitational problem is an attempt to provide a realistic description of the gravity of the Universe by moving from the two-body problem to a real system where each body attracts all others. The N-body gravitational problem is based on Newton's law of universal gravitation, $F = GmM/r^2$. This is a vicious circle: an attempt to find a realistic description of the gravity of the Universe using the two-body law as a basis. A mathematical impasse arose immediately for $N \geq 3$. A complete description of gravity requires taking into account the gravitational influence of billions of bodies in the Universe. Henri Poincoré proved that the N-body gravitational problem for $N \geq 3$ has no analytical

solution. Attempts to provide a realistic description of the gravity of the Universe using the N-body gravitational problem have been unsuccessful.

To eliminate the imperfections of Newtonian dynamics, many attempts have been made to modify Newton's law [7–13]. No modifications to the two-body law of gravity have yielded results. Neither the N-body gravity problem nor modifications of the two-body law of gravity led to the discovery of a Law of Gravity that takes into account the gravity of all bodies in the Universe.

In [14], the problem of finding the law of gravity based on the integral parameters of an N-body system was formulated. This is the inverse N-body problem. Unlike the unsolvable direct N-body problem, the inverse N-body problem has a solution. All solutions to the inverse N-body problem are given in [14]. One solution to the inverse N-body problem is the law of universal gravitation without the gravitational constant G [15].

5. How the law of gravity of two bodies came to be called the law of universal gravitation.

To Newton's credit, he did not call his proportional relationship $F_N \propto mM/r^2$ the law of universal gravitational attraction. How then did the laws of two-body gravity ($F_N \propto mM/r^2$, $F = GmM/r^2$), which do not take into account the gravity of all bodies in the Universe, come to be called the laws of universal gravitation?

Newton didn't do this. Others did. Roger Cotes, the editor of the second edition of Philosophiae Naturalis Principia Mathematica (1713), did. In the preface, he emphasizes the universality of Newton's law of gravitation. Voltaire, in his Philosophical Letters (1734), explained Newton's ideas using Hooke's concept of "*universal attraction*." Voltaire failed to mention that "*universal attraction*" is Robert Hooke's term, and it refers not to the law of gravitation between two bodies, but to the attraction between all bodies in the universe. Thus, Voltaire also authored the historical injustice that kept Hooke's contribution in the shadows for over three centuries.

Thus, thanks to the words of Roger Coates, the law of two-body gravitation, $F_N \propto mM/r^2$, and later $F = GmM/r^2$, was unjustifiably called the law of universal gravitation. But what about the real law of universal gravitation? The true law of universal gravitation, which takes into account the fact that every body in the universe attracts every other body, as Robert Hooke desired, was never discovered.

Thus, by calling the law of two-body gravitation, $F = GmM/r^2$, the law of universal gravitation, we are repeating not the words of Newton, but the words of Roger Coates, who, being a great admirer of Newton, unjustifiably called the law of two-body gravitation the law of universal gravitation.

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